EMBRYOLOGY

THE BEGINNINGS OF LIFE

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CHAPTER I

THE CELL AND THE INDIVIDUAL

WHAT is Embryology, and what is its significance or interest to the ordinary educated man and woman? The answer to the question is the justification for the appearance of the following pages, and one may regard it as a somewhat striking fact, that in the production of a series of works of which this volume is one, those responsible for the subjects should have deemed it advisable to include Embryology.

Embryology may be defined as that part of the science of Biology which deals with the formation of a new individual or embryo. The definition itself ought to be sufficient to explain the significance of the subject for every one, because one can hardly conceive of any more profoundly important knowledge than that which tells of the mode of origin, manner of growth, and ultimate birth of an entirely new being. In the absence of such accurate knowledge it is quite obvious that all one's ideas concerning the manner in which the new individual is to be treated must have a more or less haphazard, or at least empirical, basis. In fact only when Embryology, or the science of the develop-

ment of the embryo, becomes a part of the ordinary everyday mental equipment of those who are responsible for bringing into the world new individuals, and subsequently protecting and handling them, will it be reasonable to expect that these new individuals will be dealt with in the best possible manner. In a word, it is evident that education, using that term in the very widest possible sense, can never be anything more than a blind groping in the dark until those into whose hands it is entrusted realise and know at least the most important fundamental facts concerning development. It is the lack of this kind of knowledge that has been responsible for so much of the mistaken systems of the past in dealing with the young, and it is the spread of this knowledge that alone is the hope of better things in the future. Wherever knowledge is absent superstition is rife, and in no sphere of life is this more painfully obvious than in connection with the subject which we are about to study. It would have been entirely impossible for many of the stupid and even cruel methods of mental and physical treatment that have been meted out to the young children in the past to have been tolerated for a moment had this knowledge been available and sufficiently widespread. For those possessing it, a flood of light is thrown upon the fascinating and otherwise obscure problems of heredity; and thus it lays open the pages of the past for those who care to read them. For those possessing it also it throws upon the mental screen pictures of possibilities in the future for all those who have eyes to see. So the study of Embryology links up the past with the present and joins the present with the future. Is it not therefore obvious that

the study of such a subject has an importance that it is impossible to exaggerate, presenting as it does problems that the parent, the teacher, the social reformer, the politician, and the philanthropist will grapple with in vain unless they call in science to their aid? Such is the meaning and significance of the subject of our study.

In the widest sense of the word Embryology, therefore, deals with all manner of living things, be they plant or animal. But since our purpose here is to state, as far as possible in the space at our disposal, the facts which are of particular importance in relation to the human subject, we shall only glance at the rest of living creatures. A brief look at them, however, is quite necessary in order to appreciate what follows. Let us be quite clear of what we are in search. We want to know as far as possible what it is that goes to the making of a man. What is the origin of the new individual? Where does the embryo come from? What elements are concerned in its formation? Where do these elements come from? How are they subsequently built up into the type of the species to which they belong? From what source do they gain their nourishment? What influences of a degenerative nature are likely to affect them? These are the questions which it is the business of the Embryologist to answer, and these are the questions the answers to which afford the explanation of man in the making. Surely they merely require to be stated that their significance may be appreciated.

We may now glance very briefly at the simplest facts which bear upon the subject, and which must precede our detailed study. The necessity for repro-

duction and development is involved in the universal fact of death. In all except the very simplest forms of life—those consisting of one simple mass of protoplasm—the individual sooner or later perishes, and if it were not that there were some methods by means of which the individuals could give rise to new individuals obviously the species would come to an end. No matter to what great age an individual animal may live, and there are some such as the tortoises which do live for centuries, sooner or later death overtakes them, and in all, investigation of their structure shows that nature has made provision for the carrying on of the race by means of new individuals.

Every living creature, be that creature simple or complicated, animal or vegetable, man or a jellyfish, starts life as one single cell. The very simplest living individuals never consist of anything else but one single cell, and it is in these primitive forms of life alone that what we call death can not be said to occur. Such a simple cell, after living for a certain period, simply divides itself into two halves, each of which gradually assumes the size and shape of what we may term the parent cell. The first individual has simply become two separate individuals. These two in their turn after another period of independent existence, again each divide, thus giving rise to four, and so on. Now here, although the original parent cell no longer exists *as a cell*, the actual material of which it was composed still exists in the cells which came into existence as the result of this division. The original cell, therefore, may be literally said to have been deathless, or immortal, though not everlasting. This is a profound thought, and one which must be grasped

at the very commencement of our study of development, because it is one to which we shall have to recur again and again when we come to study the cells which give rise to human beings, in whom, too, there is a deathless continuity of cell protoplasm, or germ-plasm as it is then called. It is upon this fact that the whole science of Embryology depends.

The important idea to be learned from observing this process of reproduction in the single-celled animal is this: that there is nothing here which we may term the body of an animal as opposed to any of its parts. The one cell is both body and organs, and everything else; in itself it has the capacity of performing all the functions necessary for life, including that of reproduction for the perpetuation of the species. No part of the cell is set on one side for any special purpose such as happens in the bodies of higher animals. There are no special elements which go to the producing of the next generation, none of the cells which in a mammal, for example, we call "germ-cells." The whole individual is one cell. In fact one might almost say that there is no individual, but only race, or if we regard the cell as an individual then it is all germplasm. That is the important fact to be learned in the reproduction of single cells.

There are some single cells, such as those of the yeast, which reproduce in a slightly different manner, namely, by budding off a portion of themselves and finally becoming separate, and this might be regarded as a slightly higher stage, in so far as the original cell from which the bud came may be still identified; but in reality the process differs very little from that first described.

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Then we may note that very low in the scale of living things there is a process of reproduction known as conjugation, in which, although the cells of the species appear to be all alike, yet, nevertheless, two of them join together for purposes of reproduction. In other words we have here a process of cell-union before we have the cell-division which follows. It is important to note at this stage that the creatures which we have mentioned, and even some more highly organised, such as an amœba, which has a nucleus, go through these simple or complicated reproductive processes in the total absence of anything which could suggest a distinction of sex. In these cases the individuals are obviously all of one sex, and, therefore, the distinction of sexes into male and female is evidently something which has been added later in the scheme of evolution, not for the purpose of reproduction itself, but for something which is to be added to that.

Then in the slightly higher animals and plants we come to those in which many cells go to the making of the individual, the multicellular individuals, and amongst these we very soon see the origin of what is termed specialisation of function. That is to say, in these higher creatures which consist of many numbers of cells arranged so as to form one individual, certain cells are set-apart for one purpose and others for another. Some may be for digestion, some for purposes of movement, and others for reproduction. Here we have a new phenomenon, namely, the setting aside of certain cells in a multicellular individual which from the very beginning are capable of one function alone, namely, reproducing the species. The higher one goes in the scale of life the more striking and

obvious this fact becomes, and as we shall see when we come to the vertebrate kingdom, this setting aside of the cells which are to produce the individuals of the next generation is the key to the solution of the most difficult of our problems.

In these highest forms of life, however, the cell itself is becoming a much more complicated thing than that lowly form which we first noted as dividing into two to form two new individuals. Indeed, the cells in the highest animals and plants are immensely complicated in their structures and functions, and especially in connection with the changes which take place in the nucleus of such cells. Not only the nucleus but another small object within the cell which is neither part of the nucleus nor part of the cell protoplasm, also is very important, and this structure is termed the "centrosome." In fact this little body apparently begins the whole process of cell-division by itself dividing into two parts. Then the nucleus follows suit, and ultimately the whole cell divides. The nucleus itself is a complicated structure, as is especially seen during the processes of division, in which it breaks itself up into a number of thread-like portions, and the number of these is always the same in any given species, a fact which is of great importance in reproduction. Why do we mention these apparently dry details? Because in these minute and complicated nuclear movements the whole problems which are at the bottom of development and heredity lie. The problems of life itself can only be solved by the study of what takes place in these minute portions of cells. It is here that the new formation of an individual begins, and although it is no part of our

purpose here to detail all the complicated processes of nuclear division, it is essential, in order to grasp the meaning of our subject, that we should realise that in the changes within the cell life with its variations begins.

The study of these wonderful cell processes, a work which demands the most patient investigation and high technical skill, has reached such a stage that it is a science of its own, and is called the science of "Cytology," or the science of cells, which has been made possible only in comparatively recent years by the invention of microscopes having great powers of magnification, and by the application of elaborate methods of staining to the cells themselves.

We can say no more about these processes here, but the foregoing paragraphs may perhaps be sufficient to show us how important it is to grasp these simple facts of cell life in their bearing upon development itself.

CHAPTER II

PROBLEMS OF REPRODUCTION

We have seen that in the higher types of animals and plants the single individual is made up of not one but millions and millions of cells united together for the common purpose of the individual life, and that in such complicated individualities some cells perform one function while others perform others. A human individual from this point of view, therefore, is an organised community of cells all of which, however, sprang, in the first place, from one single cell. That original single cell is termed, in animal Embryology, the "fertilised ovum." It is popularly spoken of frequently as "the egg." All the other millions of cells are the direct descendants of this fertilised ovum, or egg, even though many of them eventually become extremely unlike the original cell. In single-celled animals the offspring of the original cell remain like the parent cell, but in the highly complicated creatures the offspring split up into a great many types of cells, owing to the very fact that all remain adherent together to form the mass of the body in order to carry out different functions. So we find cells of one type in glands, of another type in the brain, of another type in bones, of another type in blood, and so forth. Nevertheless all of them sprang from one original single cell. None of these

puts it, "the embryo starting from the same point, must follow the same road to reach the same goal. The embryo which did not recapitulate the history of the development of a parent would be a monstrosity."

While, however, recapitulation in development is always more or less clear, it does not follow that it is perfectly complete, nor perfectly identical with the development of the parent. Indeed, on the other hand, there is always a certain amount of variation, either progressive or retrogressive. Progressive variation means that in addition to the development of all the parental stages, something new has been added. Retrogressive variation means that from the total development experienced by the parent, something has been omitted. We are here speaking of characters of a species, and it must not be thought that we are referring to the characters of the embryo as if they were derived from those of their parents. This was clearly pointed out in the earlier portion of our study. The variations in development, to which we here refer, take their origin in the germ-plasm which tends to repeat in each generation similar types of development. In other words the germ-plasm from which individuals spring is of such a nature that the embryos arising from it show in their development a recapitulation of the evolution of their particular species. In addition they may show variations of either a plus or a minus character. These variations are frequently inherited, and persist throughout succeeding generations. In course of time, if there are many of such variations, they accumulate, and to that extent, of course, alter the life history. That is why in watching the development of a human embryo it is impossible to trace accurately the early ancestral development of the race from it. It passes through the stage of a single cell, then becomes multicellular, and gradually assumes the form of a higher and higher type of organism. "Manifestly the additions and subtractions have been vast. It possesses, for instance, a placenta, an organ by which it is attached to the mother, through which it is nourished, and which at one time is larger than the embryo itself; but which, of course, could not have been present in its prototypes. Nevertheless the life history unfolded by the child is just as real, just as complete, and probably more accurate than any written chronicle that attempts to describe the whole past of a race." (Reid.)

"There is a history in all men's lives
Figuring the nature of the times deceased."

Here we must conclude this brief sketch of some of the principal facts in the science of Embryology, in the hope that enough has been said to stimulate the interest of our readers in this subject to such an extent that they may be encouraged to pursue its study still further in one of the many text-books that are devoted entirely, or partly, to this matter.

We would urge in conclusion that the study is well worth while, even for those to whom it has a non-professional interest. It should be sufficiently obvious to any earnest thinker that the problems which are involved in the study of embryology are precisely those which are of the very greatest importance to humanity at large. With this subject is most inti-

mately bound up that of heredity itself, which has been dealt with in another volume of this series. No true understanding of what can be done, or what should be done, in the direction of improving the lot of generations to come, or of making the most of the generation at present existent, can be obtained by any who are absolutely ignorant of these topics. It is only by their study that we realise that the human embryo, which is to become the human individual, consists, to a very large extent, of characters and features which are unalterably settled for it beforehand, to which nothing can be added, and from which nothing can be taken away. In other words, the possibilities for any individual are those which are pre-existent in the germ-plasm from which he or she originates. These possibilities, however, depend upon the environment in which the embryo, infant, child, and adult is subsequently placed for their full expansion. In many directions the inherited tendencies transmitted by the continuity of germ-plasm are unalterably and strictly defined. In many other directions these inherited tendencies can be so modified, drawn out, or even partially suppressed, by suitable surroundings of a hygienic, educative, and moral nature, that if the process be taken in hand sufficiently early wonderful successes may result. These results are those for which the social reformer and the philanthropist and the serious student of sociology are earnestly striving, but it is only by a study of the sciences of Heredity and Embryology that accurate data can be obtained from which justifiable conclusions may be drawn.

The great fact which embryology teaches is that the

past is unfolded stage by stage, with certain omissions and additions, so that in very truth—

> "The softest dimple in a baby's smile
> Springs from the whole of past eternity,
> Taxed all the sum of things to bring it there."